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Indian Standard

IS 17483 (Part 1) : 2020

भुकृत्रिम — जिओसैल्स — विशिष्टि

भाग 1 भार धारण अनुप्रयोग हेतु

Geosynthetics — Geocells — Specification

Part 1 Load Bearing Application

ICS 59.080.70

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Geosynthetics Sectional Committee, TXD 30

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textiles Division Council.

Geocells are three-dimensional, permeable, polymeric (synthetic or natural) honeycomb, or similar cellular structure, made of linked strips of geosynthetics that form a confinement system when in-filled with compacted soil, aggregate and sometimes plain cement concrete, depending on the application requirement. The profile of geocells are generally curvilinear rhomboidal structures. Geocells are fabricated from extruded and textured polymeric HDPE sheets, which are UV stabilized with carbon black and are cut into strips. These strips are ultrasonically welded together in alternate intervals and in series. The strips thus fabricated form cellular panels when opened. When the cells are infilled with soil (non-plastic soils for load bearing applications), the geocell panels form semi rigid mats. The texturing and perforations of the walls of the individual cells increase the friction between the infill non-plastic soil and the geocell walls. The lateral pressures are progressively transmitted to adjoining cells to spread the imposed normal load on the geocell mat.

Geocells are used for several applications, *inter alia* flexible pavements, sub-ballast and ballast reinforcements in railways, basal reinforcements for road and rail embankments on weak soils, industrial flooring and shallow foundations, slope erosion protection, as elements for gravity walls and fascia for reinforced soil systems etc.

This standard has been prepared to provide requirements for geocells which are used in load bearing application. In the formulation of this standard, due importance has been given to global standards and practices as well as existing standards and practices in India.

This standard will help engineer in selecting geocells of appropriate quality for specific project requirements. Procurement of the geocells shall be done as per such requirements, and the material shall be selected by comparing the parametric requirements of design with the design value indicated in the manufacture’s data sheets. The contractor executing the installation of geocells shall follow the specifications and installation guidelines provided by engineer and/or by the geocell manufacturer.

The composition of the Committee responsible for the formulation of this standard is given in Annex G.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GEOSYNTHETICS — GEOCELLS — SPECIFICATION

PART 1 LOAD BEARING APPLICATION

1 SCOPE

1.1 This Indian Standard (Part 1) specifies material properties and specifications that are required for the use of high density polyethylene (HDPE) geocells for load bearing applications such as flexible pavements, reinforcements in railways, basal reinforcements below reinforced soil structures, conventional embankments on weak soils and industrial flooring and shallow foundations etc.

1.2 This standard is a specification aid for material purchase and shall not be used as design or construction guideline. Design of the load bearing applications shall be recommended to be carried out separately.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 DEFINITIONS

For the purpose of this standard following definition shall apply.

3.1 Geocells — Geocells are three-dimensional, permeable, polymeric (synthetic or natural) honeycomb, or similar cellular structure, made of linked strips of geosynthetics.

NOTE — The profile of geocells are generally curvilinear rhomboidal structures (*see* Fig. 1 and Fig. 2).

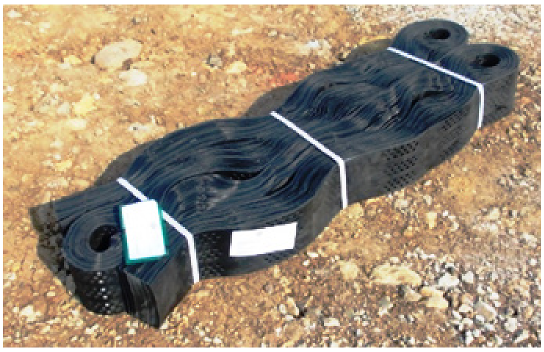


FIG. 1 GEOCELL PANEL IN COLLAPSED FORM

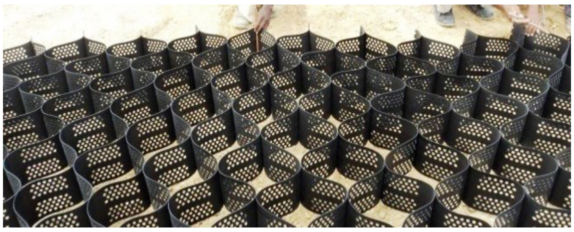


FIG. 2 GEOCELLS IN EXPANDED FORM

4 MATERIALS

4.1 The material of construction of the geocells, shall be made up of HDPE, which shall essentially exclude recycled material, impurities, intrusions and fillers.

4.2 The resin shall be virgin material with not more than 15 percent own rework. If rework is used, it shall be a similar HDPE as the parent material.

4.3 Geocells material shall be rendered resistant to UV and the HDPE from which it is fabricated shall have minimum 2 percent by weight of carbon black content when tested as per the method given in IS 2530 to inhibit attack by ultraviolet rays.

4.4 Geocells material shall be inert to all chemicals naturally found in commonly encountered soils not containing adverse solvents and at ambient temperatures. The material of construction shall not be susceptible to hydrolysis. It shall be resistant to aqueous solutions of salts, acids and alkalis and shall be non-biodegradable.

NOTE — Accessories required for complete and proper installation of geocells that are not specifically described herein (such as connectors, cable ties, J-hooks, etc) shall conform to the manufacturer's recommendations.

5 MANUFACTURE

5.1 Geocells shall be fabricated from extruded and textured polymeric HDPE sheets and are cut into strips. These strips are ultrasonically welded together in alternate intervals and in series. The strips thus fabricated form cellular panels when opened.

5.2 Geocells used for load bearing application shall have a depth ranging from 125 mm to 200 mm (*see* Note) and final geocell pockets size ranging from 300 mm to 445 mm. The following tolerance shall be permissible for depth and final geocell pockets:

Dimension	*Tolerance,* Percent
Depth	$\left\{\begin{matrix}+3\\-2\end{matrix}\right\}$
Final geocell pocket size (expanded cell)	$\left\{\begin{matrix}+3\\-3\end{matrix}\right\}$

NOTE — In specific cases such as infilling with concrete or self-compacting material, geocells of depth above 200 and up to 300 mm may also be used.

5.2.1 For effective confinement h/D_{eq} ratio shall be from 0.7 to 1.25. Equivalent diameter of the geocell pocket (D_{eq}) shall be measured by the formula as follows:

$$D_{eq} = \frac{1}{2}\sqrt{d_1^2 + d_2^2}$$

where

h = depth of the geocell;

D_{eq} = equivalent diameter of the geocell pocket;

d_1 = width of the geocell pocket; and

d_2 = length of the geocell pocket.

5.3 Texturing

The polyethylene strip shall have multiple rhomboidal indentations over the entire strip area (*see* Fig. 3 and Fig. 4) on both sides of the strip. The indentations shall have a surface density of 22 to 32 per cm^2. Asperity height of the texture when tested by the method given in Annex B shall be minimum 0.25 mm measure on one side from the core to the textured peak of the geocell sheet.

NOTE — Friction, arising due to the texturing, between the infilled material and the geocell wall plays a significant role in the effectiveness of the geocell for any application. A smooth walled geocell is not as effective as the one with textured wall.

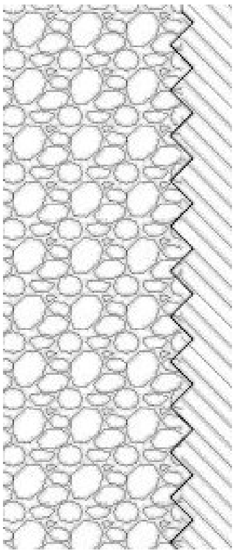


FIG. 3 SCHEMATIC DIAGRAM OF TEXTURING OF CELL WALL AND INFILLED SOIL

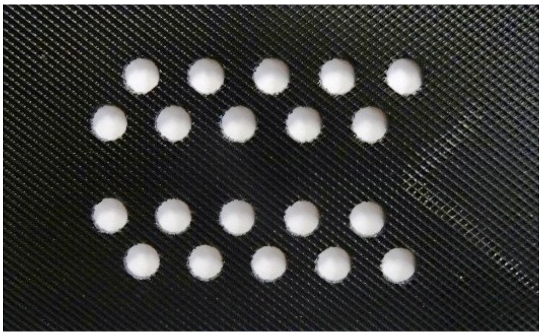


FIG. 4 TEXTURING AND PERFORATIONS ON CELL WALL

5.4 Perforations

For load bearing applications, the geocell strips shall essentially be perforated in horizontal rows as shown in Fig. 4. The maximum diameter of the circular perforations shall be 10 mm. The area of cell perforations shall be less than 12 percent of cell surface area of a complete geocell pocket strip to optimize the tensile strength of the geocell strip.

5.5 Seam Weld

The adjoining strips that form the geocell panel shall be welded ultrasonically. The seam weld thus formed shall be uniform (*see* Fig. 5). For uniform seam strength, ultrasonic weld melt pool width shall be maximum 25 mm.

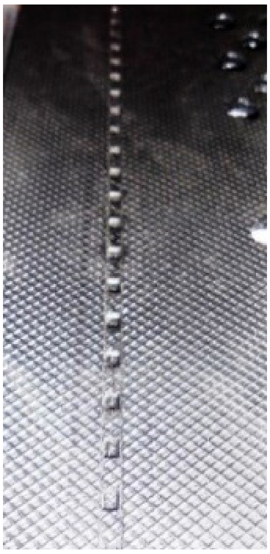


FIG. 5 ULTRASONIC SEAM WELD

6 REQUIREMENTS

6.1 Geocells shall be dimensionally stable and able to retain their geometry under manufacture, transport, and installation.

6.2 Geocells for load bearing application shall meet the requirements as specified in Table 1.

Table 1 Requirements of Geocells for Load Bearing Application

(*Clause* 6.2)

Sl No. (1)	Characteristic (2)	Requirement (3)	Method of Test, Ref to (4)
i)	Density, g/cm^3, *Min*	0.9	IS 13360 (Part 3)/Sec 10 or IS 13360 (Part 3)/Sec 11 or IS 13360 (Part 3)/Sec 12
ii)	Environmental stress crack resistance – Notched constant tensile load (ESCR - NCTL), 400 h, *Min*	Test specimen shall not fail	IS 16346
iii)	Environmental stress crack resistance (ESCR), 5000 h, *Min*	Test specimen shall not fail	Condition B of Annex C
iv)	Carbon black content, percent, *Min*	2.0	IS 2530
v)	Post texturing strip/cell wall thickness at a pressure of 2 ± 0.01 kPa, mm, *Min*	1.6	IS 13162 (Part 3)
vi)	Seam peel-strength per 25 mm of cell depth, N, *Min*	350	Method B of IS 17369 (Part 1)
vii)	Seam weld hang strength for 100 mm of seam weld under constant dead weight of 72.5 kg for 7 days at 54 ± 2 °C	Seam shall not break	Annex D
viii)	Resistance to oxidation, Retained tensile strength, percent, *Min*	90	IS 17360
ix)	Retention of breaking strength after UV exposure of 500 h, *Min*	95 percent of the original actual value	Annex E
x)	Friction efficiency, percent, *Min*	85	Annex F
xi)	Standard oxidative induction time, minutes, *Min*	100	ISO 11357-6
xii)	High pressure oxidative induction time, minutes, *Min*	400	ISO 11357-6

7 MARKING AND LABELLING

7.1 The geocell material shall be marked with the following by attaching the printed labels:

a) Identification of the geocell style like geocell depth, geocell final pocket size;
b) Style number, lot number and roll number;
c) Date of manufacture of geocell panel;
d) Any other information/instruction provided by the manufacturer;
e) Manufacturer’s name, initials or trademark; and
f) The country of origin.

7.2 BIS CERTIFICATION MARKING

The geocells conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the geocells may be marked with the Standard Mark.

8 PACKING

The geocells panels shall be packed either in pallets (*see* Fig. 6 and Fig. 7) or in collapsed sheet form (*see* Fig. 8 and Fig. 9) as per the contract or order. Each pallet shall be protected by wrapping it in a film of minimum thickness of 50 microns to prevent it from the adverse impact of heat and moisture, oil, grease, dirt, dust and other stains (*see* Fig. 6 and Fig. 7). In case of geocell in collapsed sheet form, the packing shall be as per agreement between the buyer and the seller.

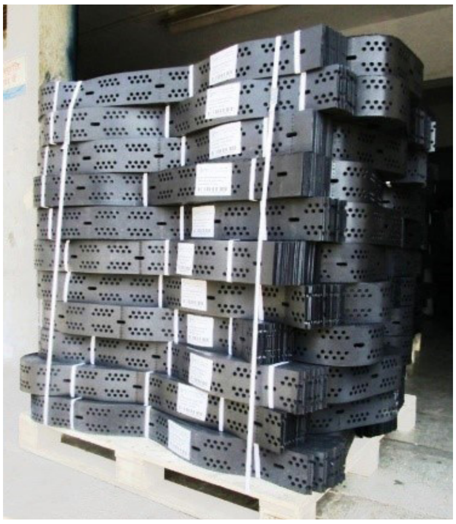


FIG. 6 FOLDED GEOCELL PANELS ON PALLETS

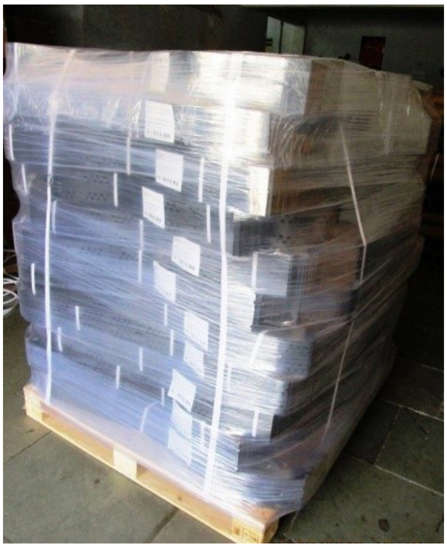


FIG. 7 PACKAGED GEOCELL PANELS ON PALLETS

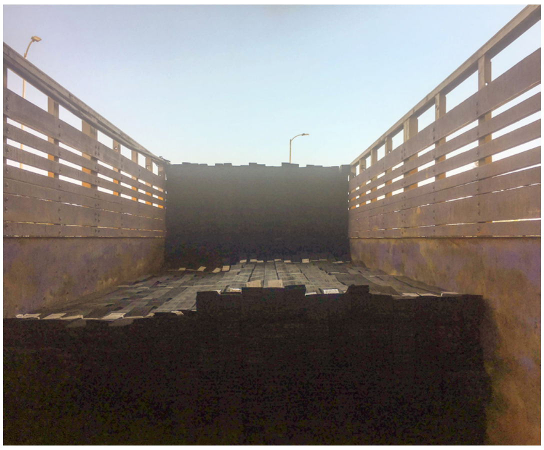


FIG. 8 GEOCELL PANELS IN SHEET FORM

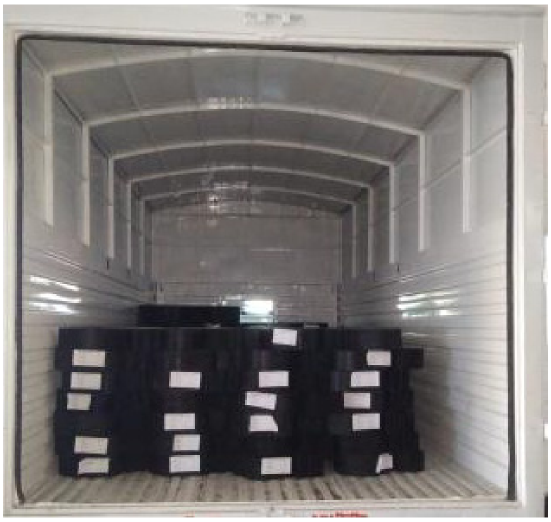


FIG. 9 FOLDED GEOCELL PANELS IN CLOSED CONTAINER

9 IDENTIFICATION, DELIVERY, STORAGE AND HANDLING

9.1 The geocells labelling, shipment, storage and handling shall be done in accordance with IS 17421.

9.2 During storage, geocells shall be elevated off the ground and adequately covered to protect from the following:

a) Site construction damage;

b) Extended exposure to ultraviolet radiations including sunlight;

c) Mud, wet concrete, epoxy, or any other deleterious materials coming in contact with and affixing to the geocells; and

d) Any other environmental condition that may physically damage the geocells or affect its properties.

9.3 Geocells shall be stored at temperatures above (–) 20 ºC and below 40 ºC.

9.4 Geocells shall not be lifted off the ground by chains and cables.

9.5 Geocells shall not be directly exposed to sunlight for a period longer than the period recommended by the manufacturer.

9.6 Each folded geocell panel shall be wrapped with material that will protect it from damage due to shipment, water, sunlight and contaminants.

9.7 Geocell panels shall be kept dry until installation. Based on site conditions, it shall be placed on polythene sheet or wooden plank or industrial flooring or flat ground.

NOTES

1 Geocells are used in industrial flooring where it can be safely placed on the wooden plank.

2 For the container yards project where the flooring is existing, geocells may be placed on floor.

3 For pavement applications in remote areas, geocells shall be placed on flat firm ground.

10 SAMPLING AND CRITERIA FOR CONFORMITY

10.1 Type Tests

10.1.1 Type tests are intended to prove the suitability and performance of a new composition, a new technique or a new construction of a geocell. Such tests, therefore need to be applied only when a change is made in raw material composition or method of manufacture of geocells.

10.1.2 One sample of the same size and same construction, selected at random shall be tested for compliance with the requirements of the type tests as given in Table 2.

Table 2 Type Tests

(*Clause* 10.1.2)

Sl No.	Description of Test	Sample Size	Requirement Clause
(1)	(2)	(3)	(4)
i)	Environmental stress crack resistance – Notched constant tensile load (ESCR - NCTL), 400 h, *Min*	1	**6.2** [Sl No. (ii) of Table 1]
ii)	Environmental stress crack resistance (ESCR), 5000 h, *Min*	1	**6.2** [Sl No. (iii) of Table 1]
iii)	Resistance to oxidation, Retained tensile strength, percent, *Min*	1	**6.2** [Sl No. (viii) of Table 1]
iv)	Retention of breaking strength after UV exposure of 500 h, *Min*	1	**6.2** [Sl No. (ix) of Table 1]

10.1.3 If the sample pass the requirements of the type test, the type of geocell under consideration shall be consideration eligible for the type approval.

10.1.4 In case if sample fails in the type test, the type of geocell shall not be approved. The manufacturer or the supplier may be asked to improve the product and resubmit the product for the type approval.

10.1.5 At the end of the validity period (that is 3 years for ESCR and ESCR-NCTL, 5 years for resistance to oxidation and resistance to UV) or earlier as may be necessary, the testing authority may call for fresh samples for type-test for the purpose of type approval.

10.2 Acceptance Test

10.2.1 Acceptance tests are carried out on the sample selected from a lot for the purpose of acceptance of the lot.

10.2.2 *Lot*

All geocell panels of same material and construction dispatched to a buyer against one dispatch note shall constitute a lot.

10.2.3 Unless otherwise agreed to between the buyer and the seller, the number of geocell panels to be selected at random from a lot shall be as given in column 3 of Table 3.

Table 3 Scale of Sampling

(*Clause* 10.2.3)

Sl No.	No. of Geocell Panels in Lot	Sample Size	Sub-Sample Size	Permissible No. of Defective Geocell Panels
(1)	(2)	(3)	(4)	(5)
i)	Up to 50	3	2	0
ii)	51 - 150	5	2	0
iii)	151 - 300	8	3	1
iv)	301 - 500	13	5	2
v)	501 and above	20	5	3

10.3 Number of Test Specimens and Criteria for Conformity

Number of test specimens and criteria for conformity shall be as given in Table 4.

Table 4 Number of Test Specimens and Criteria for Conformity

(*Clause* 10.3)

Sl No.	Characteristic	No. of Geocell Panels	Criteria for Conformity
(1)	(2)	(3)	(4)
i)	Material, manufacture, 6.1, density, carbon black content, post texturing strip/cell wall thickness and seam peel strength	According to column 3 of Table 3	The defective panels shall not exceed the corresponding number given in column 5 of Table 3
ii)	Seam weld hang strength, friction efficiency, standard OIT and high pressure OIT	According to column 4 of Table 3	All the test specimens shall pass the test

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS/ISO No.	*Title*
2530 : 1963	Methods of test for polyethylene moulding materials and polyethylene compounds
6359 : 1971	Method for conditioning of textiles
13162 Part 3 : 1992	Geotextiles — Methods of test: Part 3 Determination of thickness at specified pressures
13360	Plastics — Methods of testing
(Part 3/Sec 10) : 2016	Physical and dimensional properties, Section 10 Determination of density of non-cellular plastics — Immersion method, liquid pyknometer method and titration method
(Part 3/Sec 11) : 2016	Physical and dimensional properties, Section 11 Determination of density of non-cellular plastics — Density gradient column method
(Part 3/Sec 12) : 2016	Physical and dimensional properties, Section 12 Determination of density of non-cellular plastics — Gas pyknometer method
16346 : 2015	Geosynthetics — Method of test for evaluation of stress crack resistance of polyolefin geomembranes using notched constant tensile load test
16635 : 2017	Geosynthetics — Wide width tensile test
17360 : 2020	Geosynthetics — Screening test method for determining the resistance of geotextiles and geotextile-related products to oxidation
17369 (Part 1) : 2020	Geotextiles and geotextile-related products — Strength of internal structural junctions: Part 1 Geocells
17421 : 2020	Geosynthetics — Identification on site
ISO 11357-6 : 2018	Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)

ANNEX B

(*Clause* 5.3)

TEST METHOD FOR MEASURING ASPERITY HEIGHT FOR TEXTURED GEOCELLS

B-1 Asperity is the individual projection of polyethylene that extend above the core surface of a textured geocell resulting in the textured surface.

B-2 TEST CONDITION

Prior to the test, specimens shall be conditioned to moisture equilibrium from dry side in standard atmosphere of 65 ± 5 percent relative humidity and 27 ± 2 ºC temperature as laid down in IS 6359.

B-3 TEST APPARATUS

B-3.1 Depth Gauge — The depth gauge shall consist of following three components:

a) Dial indicator;
b) A setting block; and
c) A contact point with extension.

B-3.1.1 Dial indicator shall be capable of measuring to a depth of at least 2.5 mm with an accuracy of ± 0.01 mm.

B-3.1.2 Setting block shall have a base dimension of 50 to 63.5 mm long by 12.7 to 20 mm wide and a height of 15 mm.

B-3.1.3 Contact point with extension is 1.3 mm in diameter with the tip tapered to a point. An extension of approximately 17 mm is required to achieve the necessary travel beyond the base surface of the setting block. The contact point shall protrude at least 10 mm below the setting block when not in use in order to ensure that a 'Zero' setting is achieved.

B-4 TEST SAMPLING

B-4.1 For the sample, take a full geocell pocket strip such that a total of 10 asperity height determination (5 readings each for both sides) can be made evenly across the samples.

B-4.2 Asperity height shall be determined on both the sides of the geocells.

B-5 TEST PROCEDURE

B-5.1 Testing shall be carried out in the test conditions as specified in **B-2**. Depth gauge shall be placed on a flat rigid surface to zero the contact point with the bottom of the setting block. Geocell specimen being tested shall be placed on a flat rigid supporting surface to keep the specimen flat for the measurement.

B-5.2 Place the depth gauge on the surface of the textured geocell specimen with the long axis of the setting block perpendicular to the machine direction of the strip. Downward hand presser shall not be applied on the gauge to avoid compression of the asperities. Contact point of the depth gauge shall be brought into contact with the 'low spots' in between the asperities. Depth gauge shall be moved slightly on test specimen to obtain the local minimum reading. Repeat the above procedure within a radius of approximately 12 mm so that the total of three readings are obtained. The lowest value of these three readings shall be recorded nearest to 0.01 mm.

B-5.3 The procedure given at **B-5.2** shall be repeated for remaining readings.

B-5.4 Similarly for measuring the asperity height of other side of textured geocell, procedure given at **B-5.1** and **B-5.2** shall be repeated.

B-5.5 Average of 10 readings of specimen (5 readings each for both sides) obtained in **B-5.3** and **B-5.4** shall be calculated and reported nearest to 0.01 mm respectively.

ANNEX C

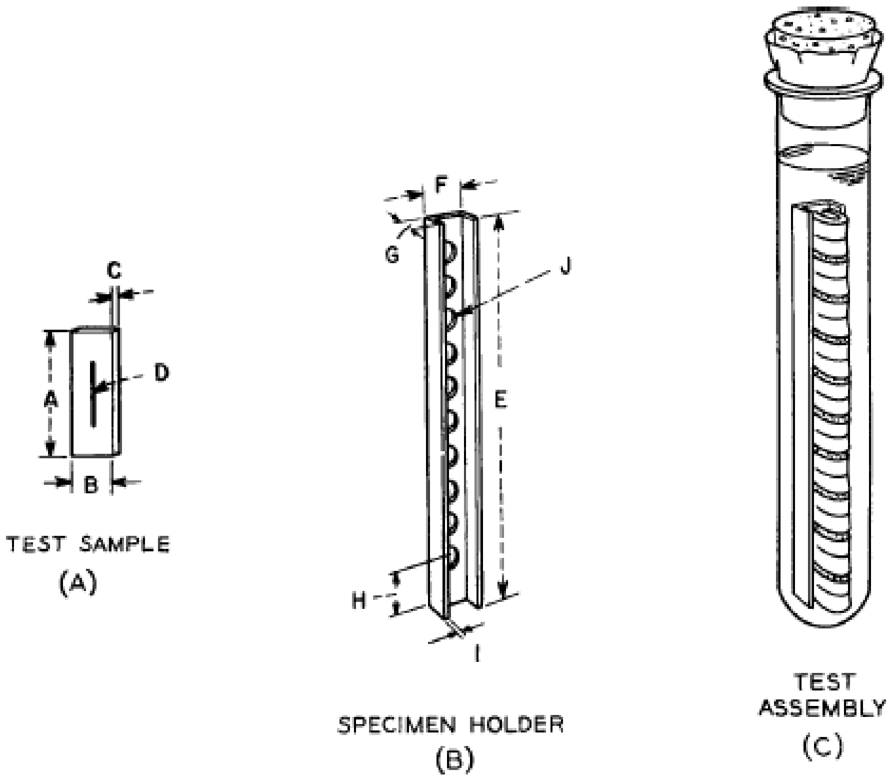
[*Table* 1, *Sl No*. (iii)]

TEST FOR DETERMINING ENVIRONMENTAL STRESS CRACK RESISTANCE

C-1 TESTING EQUIPMENT

C-1.1 Blanking Die — A rectangular die for cutting specimen 38 ± 2.5 mm by 13 ± 0.8 mm.

C-1.2 Specimen Holder — Length of half held brass channel having dimension as shown in Fig. 10.



Legend	Dimensions (mm)	
A	38 ± 2.5	
B	13 ± 0.8	
C	Refer Table 5	
D		
E	165	
F	(outside)	16
	(inside)	11.75 ± 0.05
G	10	
H	15	
I	2	
J	Ten 5 mm holes 15 mm centers	

FIG. 10 TEST EQUIPMENT

Table 5 Test Specimen

(*Clauses* C-1.2, C-1.7, C-3.1 *and* C-4)

Sl No.	Test Condition	Specimen Thickness (C), mm	Notch depth (D), mm	Bath Temperature, ºC
(1)	(2)	(3)	(4)	(5)
i)	A (*see* Note 1)	3.00 *Min*	0.50 *Min*	50
		3.30 *Max*	0.65 *Max*	
ii)	B (*see* Note 1)	1.75 *Min*	0.30 *Min*	50
		2.00 *Max*	0.40 *Max*	
iii)	C (see Note 2)	1.75 *Min*	0.30 *Min*	100
		2.00 *Max*	0.40 *Max*	

NOTES

1 For reference purposes, concentration of IGEPAL shall be 10 percent volume.

2 At a temperature of 100 ºC, a full strength reagent, rather than an aqueous solution of a reagent, is generally used because solutions tend to change their compositions by water evaporation losses during the test period.

C-1.3 Test Tubes and Closure — Hard glass tubes normally 200 mm long with a preferred diameter of 31.5 mm with a cork or a rubber stopper.

C-1.4 Constant Temperature Bath — Condition A and B are maintained at 50 ± 0.5 °C and condition C is maintained at 100 ± 0.5 °C in constant temperature liquid bath.

C-1.5 Reagent — The suitable reagent is nonylphenoxy poly (ethylene-oxy) ethanol.

C-1.6 Aluminium Foil — Approximately 0.8 to 0.13 mm thick for wrapping.

C-1.7 Jig — A jig for making a controlled imperfection in specimens of dimension shown in Table 5.

C-2 TEST SPECIMEN

The specimen shall be cut as per the dimensions given in Fig. 10. A die or other device shall be used while preparing the square specimen. The specimen shall be cut cleanly with no beveled edges.

C-3 PROCEDURE

C-3.1 Select the test condition of the specimen as ‘B’ as shown in Table 5. Each conditioned specimen shall be given a notch on one surface as shown in Fig. 10. A sharp blade shall be used to make the notch. A depth micrometer shall be used for setting the blade in the jig so that the notch depth is controlled as specified in Table 5.

NOTE — The difference between the height at the top of the blade edge and the channel of the jig where the top of the specimen rests, when being nicked, is measured to ensure the proper setting of the blade.

C-3.2 Place ten specimens, with the controlled imperfection up, in the slots provided in the bending clamp. Close the clamp by means of a vise, arbor press, or other suitable aid, taking 30 to 35 s to complete the closing operation. Place the transfer tool in top position of the closed clamp and close it over the specimens.

C-3.3 Lift the specimens from the clamp with the transfer tool and place them in the channel by releasing the transfer tool. The ends of all the specimens shall rest against the base of the brass channel. If some specimens are riding too high in the holder they shall be forced down by manual pressure.

C-3.4 Within 10 min after the specimens have been bent into the holder, insert the holder in the test tube. Then immediately fill the tube to approximately 13 mm above the top of the specimen with fresh reagent which is at a temperature of 27 ± 1 °C. Cover the tube by a stopper with a foil-wrapped cork and immediately place it in the constant temperature bath at the preselected test temperature. The controlled imperfections shall not touch the test tube during the test.

C-3.5 Inspect the test specimen at regular intervals and record the total number of failures at the elapsed time of 5 000 h.

C-4 REPORT

Report complete identification of material, manner of preparation of test sheets, reagent and its strength, test condition as per Table 5, duration of test in hours, percentage of specimens that fail at a designated time, estimated failure time in hours by observation or estimated failure time in hours by graphical calculation.

ANNEX D

[*Table* 1, *Sl No*. (vii)]

TEST FOR DETERMINING DEAD LOAD SEAM STRENGTH

D-1 TESTING EQUIPMENT

D-1.1 Clamps — The clamps for holding the specimens shall have metallic gripping surfaces with minimal serration to prevent the test specimen from slipping or moving between the gripping surfaces when held under the pressure normal to operate. The clamp dimensions shall be 25 ± 0.5 mm wider than the specimen width.

D-1.2 Tension Testing Machine — A mechanism wherein the specimen is held between two clamps and placed under constant load for a required time.

D-1.3 Circulating Air Oven — Capable of maintaining the specified temperature within ± 2 °C.

D-1.4 Machine accuracy shall not deviate more than ± 1 percent of the load.

D-2 TEST SPECIMEN

Specimen shall be minimum of 76 mm in length perpendicular to the seam, on each side of the seam. The width of the test specimen shall be 100 mm.

D-3 PROCEDURE

D-3.1 Place the specimen in the clamping device so the seam is centered between the clamps. Apply the designated load of 72.5 kg at room temperature of 23 ± 2 °C for 1 h. After that, the testing temperature shall be elevated to 54 ± 2 °C and test specimen shall be kept at this temperature for 7 days.

D-3.2 Evaluate the specimen while under tension for jaw slippage, breaks, and tears. Readjust the specimen in the clamps if slippage occurs. Discard specimens with breakage and tears, retest using a new specimen. Some materials may elongate beyond the capacity of the machine, in these cases, if readjusting the specimens in the clamps does not allow for a constant tension, test material are considered non-testable to this method. Upon completion of the tests, if lifting or separation of the seam has occurred, or the reinforcement material in the seam area has been altered, the test shall be reported as a failure. Three specimens shall be tested for each sample unit.

D-4 REPORT

The dead load seam strength shall be reported as pass or fail, indicating the load, temperature, time duration, and the seam width. Failure of any specimen shall constitute failure of this test.

ANNEX E

[*Table* 1, *Sl No*. (ix)]

UV RESISTANCE TEST

E-1 To determine the effect of UV radiation and weathering on the breaking strength, the geocells shall be exposed as given in **E-2** and **E-3**.

E-2 TEST CONDITION

E-2.1 The test shall be carried out with xenon arc apparatus. The duration of the test shall be 500 h of xenon arc exposure.

E-2.2 The exposure consists of 120 min cycles at 65 ± 5 ºC, consisting of 102 minutes of light only, followed by 18 min of water spray and light.

E-2.3 Minimum level of irradiation shall be set to 0.5 W/m^2, 1nm bandpass at 340 nm.

E-3 TEST PROCEDURE

E-3.1 Operate the xenon arc apparatus to provide 120 minutes cycle as specified in **E-2.2.**

E-3.2 Set the minimum level of irradiation to 0.5 W/m^2, 1 nm bandpass at 340 nm.

E-3.3 Take 4 complete pocket strips in the machine direction as specimens for testing. Two specimens shall be the test samples and 2 shall be the control samples.

E-3.4 Determine the original average breaking strength for the control samples as per the test method specified in IS 16635.

E-3.5 Now, expose the test samples alternatively to light and condensation in respective test cycle in continuous mode for 500 h.

E-3.6 The type of xenon arc apparatus, time and temperature of the xenon arc exposure and condensation shall be as specified in **E-2**.

E-3.7 Determine the average breaking strength for the exposed samples as per the test method specified in IS 16635.

NOTE — For samples of geocells having width less than 200 mm, same procedure laid down in **E-3** shall be followed. This shall be reported in the test report.

E-3.8 Determine the percent retention of original strength as follows:

Retention of original breaking strength, percent =

$$\frac{b}{a} \times 100$$

where

a = average breaking strength before exposure as obtained in **E-3.4**, and

b = average breaking strength after exposure as obtained in **E-3.7**.

ANNEX F

[*Table* 1, *Sl No.* (x)]

TEST FOR DETERMINING FRICTION EFFICIENCY OF TEXTURED GEOCELLS

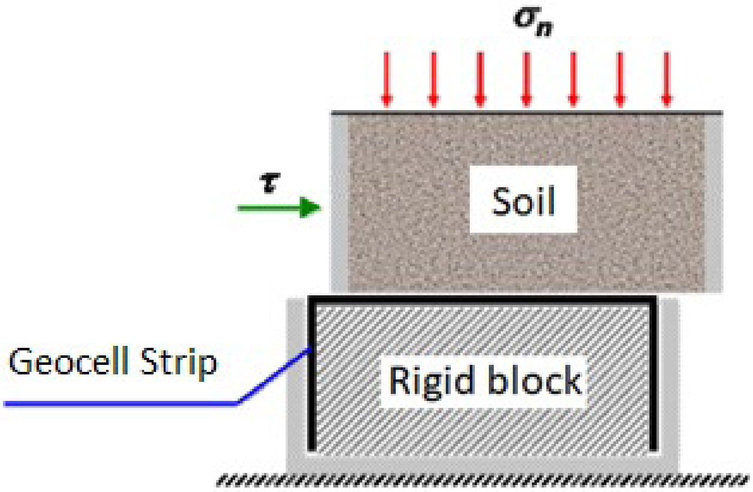
F-1 TESTING EQUIPMENT

F-1.1 Shear Box Apparatus — The shear box apparatus with fixed box arrangement having upper and lower sections sufficiently rigid enough to resist the distortion under applied load. It shall have a provision for lifting the upper section of shear apparatus from lower section (*see* Fig. 11).

F-1.2 Machine accuracy shall not deviate more than ± 1 percent of the load.

F-2 TEST SPECIMEN

F-2.1 Textured geocell strip with perforation area less than 12 percent of the cell surface area.



σ_n = Normal stress in the shear plane
τ = Interface shear strength (geocell-soil)

FIG. 11 SCHEMATIC DIAGRAM OF DIRECT SHEAR TEST WITH FIXED BOX ARRANGEMENT

F-2.2 As a construction material, sand is used for this procedure.

NOTE — Granular material with known friction angle (for example - natural silica sand, gravel etc) may also be used.

F-3 PROCEDURE

F-3.1 Fix the specimen with support system. Fill the lower part of apparatus with pre-weighed mass of sand such that when compacted, achieves the density of 70 to 90 percent and occupies the required volume.

F-3.2 Now assemble the upper half of the apparatus. To avoid the friction between the two halves of the apparatus, upper part shall be flush with the lower part of the shear apparatus.

F-3.3 Fill the upper part of apparatus with pre-weighed mass of sand such that when compacted, achieves the density of 70 to 90 percent and occupies the required volume.

F-3.4 It is recommended to perform a series of minimum three tests (each one of them with a new sand sample) with different normal stresses (σ_n) to obtain sand-sand friction angle.

F-3.5 It is recommended to perform above three tests under three different normal loading condition to model appropriate field conditions. The limiting value of shear stresses are plotted against applied normal compressive stresses used for testing. These results are generally represented by a best fit straight line whose slope is coefficient of friction between two materials where shearing has occurred on x coordinate and y-intercept of the straight line is the adhesion and calculated as shown in equation below.

$$\tau = c_a + \sigma_n \times \tan \delta$$

where

σ_n = normal stress in the shear plane;

τ = interface shear strength at peak–soil to soil/ geocell to soil;

c_a = adhesion between soil to soil/geocell to soil; and

δ = interface friction angle between soil to soil/ geocell to soil.

F-3.6 The results obtained in these tests (*see* **F-3.5**) are similar to those shown in Fig. 12. From the values of the peak and residual (post-peak) shear stress shown in the Fig. 13, the Mohr-Coulomb failure envelope can be determined as shown in Fig. 13.

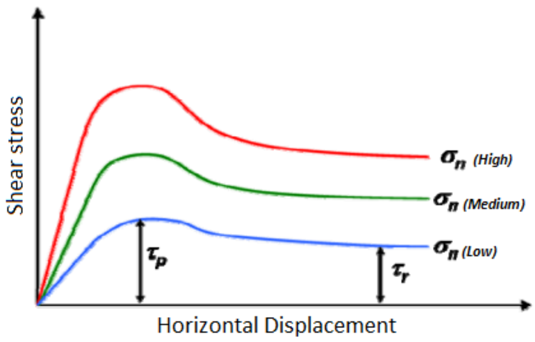


FIG. 12 TYPICAL CURVES OBTAINED BY DIRECT SHEAR TEST

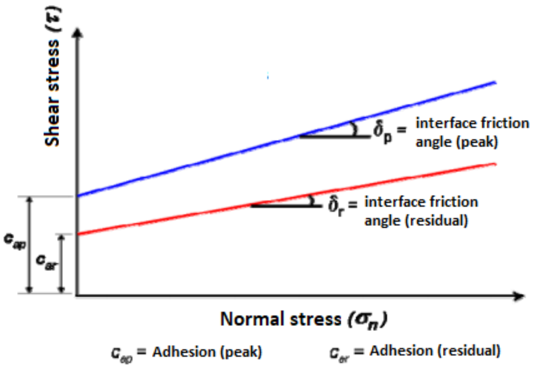


FIG. 13 TYPICAL FAILURE ENVELOPE OBTAINED BY DIRECT SHEAR TEST

where

σ_n = Normal stress in the shear plane;

τ_p = Interface shear strength at peak – soil × soil;

c_{ap} = Adhesion between soil and soil at peak;

δ_p = Interface friction angle between soil and soil at peak;

τ_r = Interface shear strength at residual (post peak) – geocell × sand;

c_{ar} = Adhesion between the geocell and the sand at residual (post peak); and

δ_r = Interface friction angle between geocell and sand at residual (post peak).

F-3.7 For sand-geocell friction angle, the procedure as given in **F-3.1** shall be repeated.

F-3.8 Now the cut specimen of the textured geocell strip (*see* **F-2.1**) shall be placed on the lower filled box and shall be fixed with the rigid support system (*see* Fig. 14).

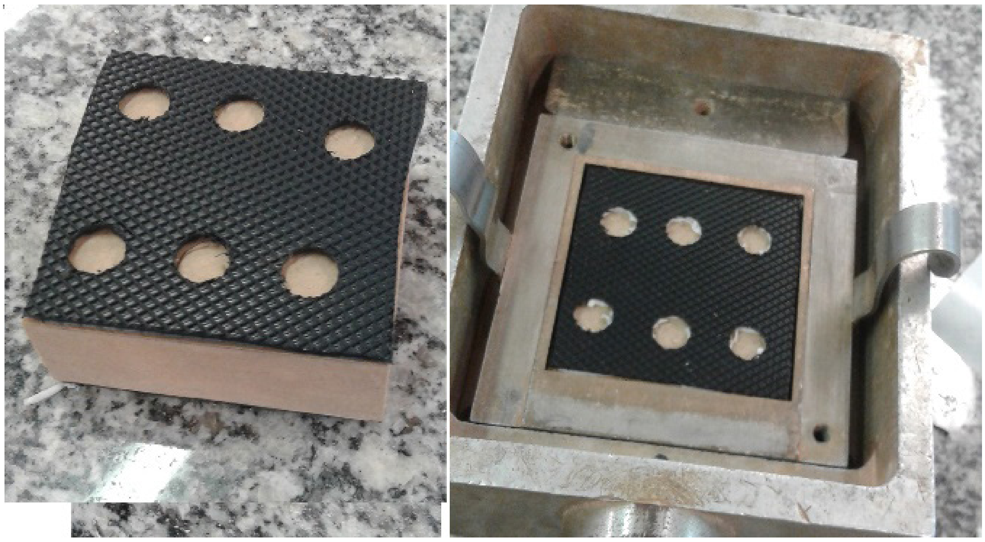


Fig. 14 Placement of Geocell with Known Perforated Area in Shear Box

F-3.9 Now repeat the procedure given in **F-3.2**, **F-3.3** and **F-3.4**.

F-3.10 It is recommended to perform a series of at least three tests (each one of them with a new sand sample) with different normal stresses (σ_n) to obtain sand-geocell friction angle. Results obtained from this test will be similar to the one shown in Fig. 13 and Fig. 14.

F-3.11 Determine friction efficiency as follows:

Friction Efficiency, $\eta = \delta_{ss} / \delta_{sg}$

where

η = friction efficiency in percentage;

δ_{ss} = sand-sand friction angle as obtained in **F-3.6**; and

δ_{sg} = sand-geocell friction angle as obtained in **F-3.10**.

F-4 REPORT

The report for friction efficiency shall be reported in percentage. It shall also include, the different loading condition, temperature, orientation of the specimens, graph of shear stress against relative displacement, graph of maximum shear stress against normal stress for all tests conducted, the angle of friction, δ_{ss} or δ_{sg}, and the apparent cohesion c_{sg} for the sand/geocell or the specific soil/geocell interface, clearly define mode of failure and where shearing occurred, observations of any damage of the specimen or unusual behavior during testing and any deviation from this procedure leading to failure of any specimen shall constitute failure of this test.

ANNEX G

(*Foreword*)

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